The Orthopteran families may then be placed in the following descending order: Gryllides, Locustariæ, Acrydii, Phasmida, Mantides, Blattariæ, Forficulariæ.

This order, if we omit the Forficulariæ and assume that Burmeister proceeded from the lower to the higher groups in his treatment of insects, is exactly the position assigned to them by that distinguished German entomologist.

January 6, 1869.

The President in the chair. Thirty-four members present.

Professor Carl Wedl of Vienna, Mr. John Cassin of Philadelphia, Hon. Lewis H. Morgan of Rochester, N. Y., and Dr. Burt G. Wilder of Ithaca, N. Y., were elected Corresponding Members.

The following gentlemen were elected Resident Members: Mr. Frederic Amory of Brookline, Mr. James W. Lovering of Cambridge, Mr. Charles F. Gerry of Hyde Park, Drs. Gustavus Hay, William W. Howard, Arthur H. Nichols, George L. Underwood and George F. Waters, and Messrs. H. J. Burton, Jr., James Chadwick, Benjamin F. Dwight, Augustus Hemmenway, George B. Knapp, Stephen C. Martin, Ernest Papendick, Frank H. Thomas and Solon Thornton of Boston.

The following paper was read:—

On the Land-slides in the Vicinity of Portland, Maine. By Edward S. Morse.

The occurrence of another land-slide in the vicinity of Portland, renders this area of considerable interest to the geologist, since this is the third slide that has happened in this region within the space of thirty-seven years. While studying the nature and causes of the recent slide, I became interested in the evidences of prehistoric land-slides, which have modified considerably the surface features of that district.

The first land-slide of which we have any account, occurred on the north bank of the Presumpscot River, above Pride's Bridge, on the night of the fifth of May, 1831.

There are two descriptions of this slide, one of which is contained in a paper entitled "Geology of Portland and Vicinity," by Prof. Edward Hitchcock, and published in the first volume of the Society's Journal. The other account is contained in Dr. Charles T. Jackson's Report on the Geology of Maine. We extract the following from Dr. Jackson's Report. "The season is said to have been uncommonly wet, and the clay, probably loosened by the frosts of winter, was rendered slippery, so that when its hold was broken it glided forward into the river. The waters of this stream were stopped in their course, and so dammed up as to overflow their banks and alter the channel to the southeastward. On examination we find no less than twelve winrows, or long masses of clay which have been precipitated forward, and the stumps of trees remaining all point toward the river.

"One of the trees on the border of the stream stands inclined at an angle of 40° from the perpendicular, and toward the stream. The space left by this slide is one hundred and twenty yards in diameter, and the clay banks exposed are elevated thirty feet above the river.

"The lower bed of clay was of a dark blue, and very tenacious and plastic, while the upper beds are more sandy, and of a light gray color." Prof. Hitchcock's account of this slide differs only in two important particulars: that the trees on the ridges all inclined toward the bank, and from the river, and that he was informed that the slide occurred in time of drought.

Prof. Hitchcock is unquestionably right regarding the direction of the trees, and judging from circumstances connected with the more recent slides, Dr. Jackson had the best information regarding the character of the season. This slide is designated on the map accompanying this paper as the "Slide of 1831."

On Tuesday, the fifth day of June, 1849, a land-slide occurred on the southern bank of the Stroudwater River, a mile west of the village of S., and about five miles from Portland. We extract the following account of its appearance from the "Portland Transcript" of that time, a paper that has always contained thoroughly reliable data of events of this nature.

"The first view presented by this slide is a perpendicular descent of over twenty feet, while immediately beneath, and in front, and stretching along what was formerly the declivity of the ridge, is a chaotic mass of blue clay, intermixed with some water and a little

LANDSLIDES
IN THE VICINITY OF
PORTLAND MAINE
1868.

1 Mile

AMMONCONCIN LANDSLIDE
Nov. 22nd 1866.

REDUCED FROM PLAN
made by
HIRAM F MILLS Hydraulic Engineer

NOTE. The shaded portion represents Sunken area just above. The darker portion being Sunken area.

To illustrate Edward S. Morse's paper on the
LANDSLIDES IN THE VICINITY OF PORTLAND, MAINE,
in the Proceedings of the Boston Society of Natural History
Vol XII Jan. 6. 1869.

sand. The impression it gives the beholder is, that as the land began to sink, the upper portion rushed swiftly down towards the little brook which ran at the foot of the ridge, and in its progress was entirely turned under, while the clay at the bottom came upon top. Scarcely a vestige of the sod is to be seen. In the rapid descent, large trees were carried down, overturned, and in some cases buried in the clay. In one instance a large pine was carried with great force between two trees but two or three feet apart, stripping off the branches upon either side, and burying the top some five or six feet in the earth beyond. The appearance of the upturned earth is billowy, and it is evident that the different strata of soil have been pretty thoroughly mixed up. The brook, now forced from its bed, creeps along the edge of the ruins, while immediately on the opposite bank arises a somewhat abrupt ridge covered with a thick growth of pines." Another report says that the phenomenon was preceded by several loud reports followed by heavy rumbling sounds, resembling thunder. This slide is designated upon the map as the "Slide of 1849." Its area was estimated at seven acres.

On the 22d day of November, 1868, another land-slide occurred on the north bank of the Presumpscot River, above the slide of 1831, and about a third of a mile below the village of Congin, or more properly Ammoncongin. This slide was much greater in extent than those already spoken of. The bed of the river, some two hundred feet in width, was filled for nearly half a mile with the débris. The contour of the sunken area is quite different from the other slides, as will be seen by referring to the map. As one looks into this chasm from the banks above, the appearance is startling. On a large portion of the sunken area, the trees stand nearly vertical, but here and there occur long ridges of soil bearing upon them the trees, inclining at various angles, many of the trees prostrate, and the intervals between the ridges filled with the light, upturned, plastic clay, or huge, square blocks of the unaltered clay. In one place may be seen a portion of an old wood road, with a large pile of cut wood, but little disturbed. Looking toward the river from the sunken area, the sight is singularly wild, for here the masses of earth have been forced out, the ridges of earth crowding upon each other, and trees and shrubs are broken, bent and turned in every direction. A few stately elms on the intervale beyond, show marks of the soft clay four feet above the present level of the surrounding clay, as if this mass surged out in billows, or else a considerable subsidence of the débris had taken place since its movement. These trees have entwined about them

smaller trees that were caught by the elms as the torrent of clay swept by. This slide proved very destructive to property, damaging valuable intervale land by its overflow upon it, and by the complete obliteration of the river bed, forming a dam which caused the river to rise some fifteen or seventeen feet, thereby flooding the lower floors of the Cumberland paper-mill, and for a time completely checking its operations. The sunken area measures about eight hundred and forty thousand square feet, and extends back from the river a third of a mile. As in the slides of 1831 and 1849, the substratum consisted of blue clay, above which was a stratum of sandy loam. We have given these general descriptions of the three slides so that one may be better prepared to understand the causes which led to them. Let us now examine a few of the prominent features presented by these disturbances.

Fig. 1. Sketch of the Ammoncongin Land-slide.[1]

The sunken portion is broken up by ridges running parallel to the exposed banks of the slide, except where the mass is forced into the the river, and there these ridges are overturned, and oftentimes buried. These ridges consist of the surface soil unaltered, bearing upon them the trees, or whatever they originally supported. The

[1] Fig. 1 is reduced from a sketch by my brother, taken from within the sunken area, looking towards the river. It shows very clearly the character of these ridges.

space between these ridges is filled with semi-fluid clay, quite different in condition from the same beds exposed in the banks. These ridges indicate that the slide was not simultaneous, but in detached portions.

A portion of the bank nearest the river first falls, the harder clay above, with the sand and compacted soil, holding together. It slides on an incline, the lower portion being crowded into the river bed; this turns the original ground surface of the mass from the river, and toward the embankment. Another portion falls, forcing up the semi-fluid clay beneath, and perhaps partially burying the first fall, and thus section after section of the land falls until the accumulated débris checks all further progress. As these separate masses fall they force into the river those portions which first fell. In the Ammoncongin slide, the clay and soil were urged down the river quite two thousand feet, and up the river nearly sixteen hundred feet. The embankments of this slide at its outlet are nearly perpendicular, and over thirty feet in height. At its upper end the embankment is twenty-five feet in height, and rises one foot in five from the surface of the sunken area to the upper surface of the clay strata; here the embankment becomes nearly vertical, the vertical portion being confined to the overlying sand, which is about ten feet thick, and this latter feature obtains around the entire embankment. I am indebted to Mr. Hiram F. Mills, Hydraulic Engineer, for these figures, and for the privilege of reducing the plan of the Ammoncongin slide from his surveys. I have roughly estimated the superficial area of the ejected clay at fifteen hundred thousand square feet. Immediately at the mouth of the slide, and in the centre of the old river bed, the clay stands twenty-five feet above the water level, besides covering a large extent of intervale to a considerable depth.

Thus while the phenomena have the appearances of a slide, the evidences are that it is only a "slump" or fall, caused by the softer clay beneath yielding to the pressure above, and being forced out by the weight of the superincumbent mass.

Prof. Dana, in his Manual of Geology, states precisely the character of these movements in the following words: "A clayey layer, overlaid by other horizontal strata, sometimes becomes so softened by water from springs or rains, that the superincumbent mass by its weight alone presses it out laterally, provided its escape is possible, and sinking down, takes its place." p. 649. And he cites a subsidence of this kind that occurred near Tivoli on the Hudson River in 1862.

In a discussion before this Society, participated in by Mr. T. T. Bouvé

and Dr. Chas. T. Jackson, the opinion was advanced that these slides might be partially due to the washing away of the substratum. If this were so, we must suppose a chasm to be worn out, and such conditions would be followed up by successive and repeated cavings in of the embankments, and we should expect to see the widest area of the slide bordering the river, while in this last event the area widens as it recedes from the river, and the occurrence evidently occupied but a short time. The softening of the substratum may be partially due to the proximity of the river, but the almost impervious nature of the clay tends to the accumulation of water, and boggy ground above; in the cases above cited, the surface was wet and boggy, and the drainage from these areas passed under the sand, and over the clay.[1] As above remarked, the character of the substratum obstructs free drainage. Thus on the occurrence of long continued rains (a circumstance noticed in two of the above mentioned slides), the clay is reduced to a semi-fluid mass, and the slide occurs as a natural sequence.

If the causes of these slides be rightly interpreted, it follows that where a clay bank of sufficient height borders a river, a slide may be anticipated; for the presence of a clay bank tends to the accumulation of water upon its surface, and the river has cut, or is cutting away the natural prop that would otherwise hold it in place. These slides would have been disastrous to life had they occurred in inhabited regions. In the case of the Ammoncongin land-slide, the damage was estimated at over one hundred thousand dollars, and the checking of the Cumberland paper mills, by which three hundred operatives were thrown out of employment, and losses estimated at one thousand dollars per day incurred. A gang of one hundred and fifty men were required to aid in the opening of a new channel on the intervale, and this has been accomplished.

Since three of these slides had occurred within the space of thirty-seven years, there was every reason to believe that traces of other slides might be detected, and we now proceed to their examination.

Mr. C. B. Fuller called my attention to a gorge below the one of 1868, which was evidently an old slide. Mr. George W. Hammond, the agent of the mills, has called my attention to one revealed by the

[1] In conversation with Mr. Mills, he expressed his opinion that the clay beneath these slides was always in this semi-fluid condition, and that the river in its action tapped these regions, as it were, allowing it to escape.

cutting of a new channel across the intervale opposite the Ammoncongin slide. At a depth of six or seven feet, the workmen came upon sticks and logs, turf and other material, indicating their burial by a slide, the chasm of which, he thinks, was evident in a gully that ran back from the intervale at that place. Several other gullies of like character have been noticed on the river by my brother, Mr. G. F. Morse.

There are traces, however, of two slides of great magnitude, one of which has quite changed the former course of Presumpscot River, as we shall presently see. One of these slides occurred within the city limits of Portland, and has formed the abrupt embankment of Bramhall's Hill. Mr. C. B. Fuller and others have oftentimes remarked the evidences of a slide at this place.

A few weeks since I made a special examination of this spot, and Fig. 2 gives a sectional view of it through the line A—B on the map. *a* represents the embankment over one hundred feet in height, *b* the lateral ridges so characteristic of these slides, and *c* the level mass of clay forced out by the action.

In this view, all the characteristics of a land-slide are as plainly seen as if the slide occurred but yesterday. On looking down from the embankment, the lateral ridges are seen to front the embankment only. While examining this slide from the point marked A on the map, my attention was attracted to the evidences of a river once running through Deering's Oaks, and into Back Cove. In Fig. 3 I have represented a sectional view through the line C—D, on the map. This shows clearly a broad river bed. As one passes over the Portland and Rochester Railroad bridge, and examines the estuary across which the bridge is built, he cannot help remarking the evidences of the former presence of a river at that place, pouring into Back Cove. The traces of a terrace still plainly exist. To the west of this region are scattered brick-yards, and the whole surface is low and clayey, the surface sand being quite removed, and, as I believe, by a series of land-slides. All these evidences prove that at one time a large body of water poured through this region, cutting out the long estuary called the Fore River, producing the Bramhall slide, and, at one time, on being turned aside through Deering's Oaks, assisting, at least, in wearing out the estuary called Back Cove. Certainly the Stroudwater River is too small a stream to have produced these results, since it has no natural reservoir, and drains but a small portion of country.

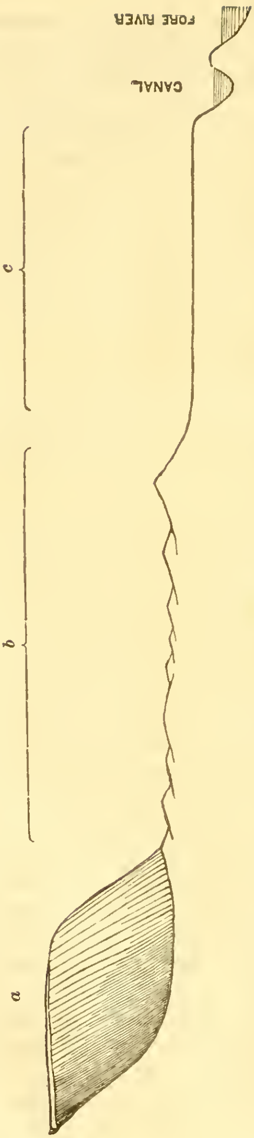

Fig. 2. Section through A—B. (See map.)

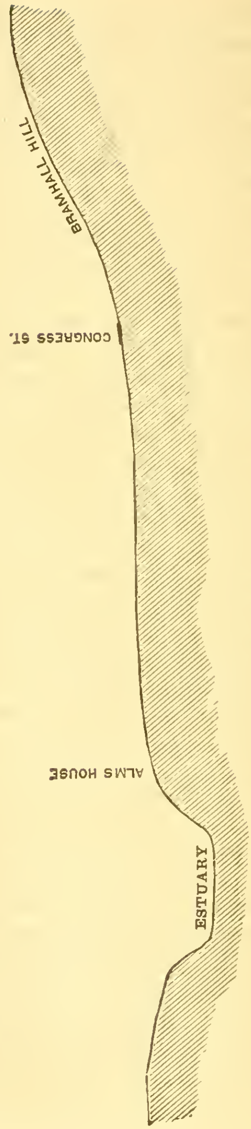

Fig. 3. Section through C—D. (See map.)

My brother, who is quite thoroughly versed in the surface features of this region, concurs with me in the opinion that at one time the Presumpscot river flowed through these estuaries, and originally formed the Fore River estuary.

An additional proof of this is seen in the traces of another slide of great magnitude, which we believe first turned the Presumpscot River into its present course. (The embankments of this slide on the map surround the name Saccarappa.) The outlet of this slide is occupied by the village of Saccarappa. It will be noticed that this slide occurred on the south side of the river, at the precise angle, and is of sufficient magnitude, to have produced these results. And furthermore, my brother has partially traced the old bed of the river commencing south of Saccarappa, and running through the marshy land whose waters empty into Fore River. The supposed old channel is dotted on the map.

As to the evidences of the Saccarappa slide, they are of the most positive character. In the first place, the village rests on a level plain of clay, and bordering this on all sides is an embankment from ten to twenty feet in height. The upper portion of this depression has always been called by the inhabitants Warren's Cellar, and indeed many have regarded this area as sunken land. In digging wells and sewers, trunks and branches of trees are met with at a depth of thirty feet from the surface. My brother sends me a birch stick, and says: "It was dug out at a depth of twelve feet from the surface, and about one eighth of a mile from the present bed of the river. A great many pieces of wood have been found in digging for a sewer. Some loam has been found, but not much. I saw one leaf that was dug out; it was quite fresh. . . . I think there are evidences of another slide running to the south of the Saccarappa slide, and if this is the case, it would lend additional proof to the hypothesis that the river formerly had a southerly course." Another gentleman informs me that he saw a number of leaves of the *Gaultheria procumbens*, which were still green, taken at a depth of thirty feet. Some bones, presumed to be those of a bear, were also found. I have rudely estimated the superficial area of the slide at one hundred and eighty-three acres.

The whole region presents a vast amount of material for study, and we trust that accurate surveys may be made, tracing out these older slides. Additional data may be expected in the course of another year, as my brother will, if leisure allows, follow up to a definite con-

clusion the speculations already advanced regarding the ancient course of the Presumpscot River.

[Note.—From certain points to which my attention was called by Mr. Mills, I am led to believe with him, that in the case of the Ammoncongin slide the movement was quite simultaneous; that the weight of the superincumbent strata of clay and sand pressed out the semi-fluid mass laterally, the sunken area settling with slight lateral motion excepting near the mouth, leaving the sides nearly vertical; and that the ridges at present bordering the bottom of the sunken space are the result of subsequent action.]

Mr. W. H. Niles stated that some workmen recently engaged in boring a well at Fort Warren, had discovered some well preserved shells of *Natica heros*, *Venus mercenaria* and *Cardita borealis*, one hundred feet below the surface of the earth, and just above the slate rock common in the vicinity. He believed this to be the greatest depth from which such remains had been drawn.

January 20, 1869.

Vice President Mr. T. T. Bouvé in the chair. Forty-five members present.

The Vice President announced the death of Mr. John Cassin, recently chosen a Corresponding Member.

Dr. T. M. Brewer addressed the Society as follows:—

Mr. President:—

With the deepest appreciation of the irreparable loss which American Science has sustained, even more than with an overwhelming sense of personal bereavement and grief, I appear before you to-night to announce the death of one who, by common consent, has been acknowledged to be the first in rank among American ornithologists. John Cassin